

CLAIMS

SubA7
1. A heat sink material comprising carbon or
allotrope thereof and metal (14),

5 wherein an average coefficient of thermal conductivity
of those in directions of orthogonal three axes, or a
coefficient of thermal conductivity in a direction of any
axis is not less than 160 W/mK.

10 2. The heat sink material according to claim 1,
wherein said average coefficient of thermal
conductivity of those in said directions of said orthogonal
three axes, or said coefficient of thermal conductivity in
said direction of any axis is not less than 180 W/mK, and
15 wherein a coefficient of thermal expansion is 1×10^{-6}
to $10 \times 10^{-6}/^{\circ}\text{C}$.

20 3. The heat sink material according to claim 1,
wherein said allotrope is graphite.

4. The heat sink material according to claim 1,
wherein said allotrope is diamond.

25 5. The heat sink material according to claim 1,
wherein said carbon or said allotrope thereof has a
coefficient of thermal conductivity of not less than 100
W/mK.

SubA87

5. The heat sink material according to any one of claims 1, 3, and 5, wherein said heat sink material is constructed by infiltrating a porous sintered member (12) with said metal (14), said porous sintered member (12) being obtained by sintering said carbon or said allotrope thereof to form a network.

7. The heat sink material according to claim 6, wherein a porosity of said porous sintered member (12) is 10 to 50 % by volume, and an average pore diameter is 0.1 to 200 μm .

8. The heat sink material according to claim 6 or 7, wherein as for volume ratios between said carbon or said allotrope thereof and said metal (14), said volume ratio of said carbon or said allotrope thereof is within a range from 50 to 80 % by volume, and said volume ratio of said metal (14) is within a range from 50 to 20 % by volume.

9. The heat sink material according to any one of claims 6 to 8, wherein an additive is added to said carbon or said allotrope thereof for decreasing a closed porosity when said carbon or said allotrope thereof is sintered,.

10. The heat sink material according to claim 9, wherein said additive for decreasing said closed porosity is

SiC and/or Si.

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11. The heat sink material according to any one of
claims 1, 3, and 5, wherein said heat sink material is
constructed by infiltrating a preformed product with said
metal (14), said preformed product being prepared by mixing
water or a binder with powder (12b) of said carbon or said
allotrope thereof, and forming an obtained mixture under a
predetermined pressure.

12. The heat sink material according to claim 11,
wherein an average powder particle size of said powder
(12b) of said carbon or said allotrope thereof is 1 to 2000
 μm , and

wherein a length ratio is not more than 1:5 between a
direction in which said powder (12b) has a minimum length
and a direction in which said powder (12b) has a maximum
length.

13. The heat sink material according to claim 11 or
12, wherein as for volume ratios between said carbon or said
allotrope thereof and said metal (14), said volume ratio of
said carbon or said allotrope thereof is within a range from
20 to 80 % by volume, and said volume ratio of said metal
(14) is within a range from 80 to 20 % by volume.

14. The heat sink material according to any one of

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claims 1, 3, and 5, wherein said heat sink material is constructed by mixing powder (12b) of said carbon or said allotrope thereof with said metal (14) dissolved into a liquid state or a solid-liquid co-existing state to obtain a mixture, and casting the obtained mixture.

15. The heat sink material according to any one of claims 6 to 14, wherein a closed porosity is not more than 12 % by volume.

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16. The heat sink material according to any one of claims 6 to 15, wherein an element for improving wettability at an interface is added to said metal (14).

17. The heat sink material according to claim 16, wherein said element to be added for improving said interface wettability is one or more of those selected from Te, Bi, Pb, Sn, Se, Li, Sb, Tl, Ca, Cd, and Ni.

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18. The heat sink material according to any one of claims 6 to 17, wherein an element for improving reactivity with said carbon or said allotrope thereof is added to said metal (14).

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19. The heat sink material according to claim 18, wherein said element to be added to improve said reactivity with said carbon or said allotrope thereof is one or more of

those selected from Nb, Cr, Zr, Be, Ti, Ta, V, B, and Mn.

Sub A11
5 ~~20. The heat sink material according to any one of claims 6 to 19, wherein an element, which has a temperature range of solid phase/liquid phase of not less than 30 °C, is added to said metal (14) in order to improve molten metal flow performance.~~

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element and said metal (14) is obtained by segregation or the like after a heat treatment, processing, and reaction with carbon, and the alloy has a coefficient of thermal conductivity of not less than 10 W/mK.

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Sub 137
26. The heat sink material according to any one of claims 1 to 5, wherein said heat sink material is constructed such that powder (12a) of said carbon or said allotrope thereof is mixed with powder (14a) of said metal (14) to obtain a mixture and the obtained mixture is formed under a predetermined pressure.

27. The heat sink material according to claim 26, wherein an average powder particle size of said powder (12a) of said carbon or said allotrope thereof and said powder (14a) of said metal (14) is 1 to 500 μm .

28. The heat sink material according to any one of claims 1 to 5, wherein said heat sink material is constructed such that a pulverized cut material of said carbon or said allotrope thereof is mixed with powder of said metal (14) to obtain a mixture and the mixture is formed at a predetermined temperature under a predetermined pressure.

29. The heat sink material according to any one of claims 26 to 28, wherein as for volume ratios between said

carbon or said allotrope thereof and said metal (14), said volume ratio of said carbon or said allotrope thereof is within a range from 20 to 60 % by volume, and said volume ratio of said metal (14) is within a range from 80 to 40 % by volume.

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30. The heat sink material according to any one of claims 26 to 29, wherein said coefficient of thermal conductivity is not less than 200 W/mK, and a coefficient of thermal expansion is 8×10^{-6} to $14 \times 10^{-6}/^{\circ}\text{C}$.

31. The heat sink material according to any one of claims 26 to 30, wherein an additive making it possible to perform re-sintering after formation, is added to said carbon or said allotrope thereof.

32. The heat sink material according to claim 31, wherein said additive making it possible to perform said re-sintering after said formation is SiC and/or Si.

33. The heat sink material according to any one of claims 26 to 32, wherein a low melting point metal for improving wettability at an interface is added to said metal (14).

34. The heat sink material according to claim 33, wherein said low melting point metal is one or more of those

selected from Te, Bi, ~~Pb, Sn, Se, Li, Sb, Se, Tl, Ca, Cd,~~
and Ni

Sub A157
5 ~~35. The heat sink material according to any one of
claims 26 to 34, wherein an element for improving reactivity
with said carbon or said allotrope thereof is added to said
metal (14).~~

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36. The heat sink material according to claim 35,
wherein said element for improving said reactivity with said
carbon or said allotrope thereof is one or more of those
selected from Nb, ~~Cr, Zr, Be, Ti, Ta, V, B, and Mn.~~

Sub A167
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37. The heat sink material according to any one of
claims 26 to 36, wherein an element having a temperature
range of solid phase-liquid phase of not less than 30 °C is
added to said metal (14) in order to improve molten metal
flow performance.

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38. The heat sink material according to claim 37,
wherein said element to be added is one or more of those
selected from Sn, P, ~~Si, and Mg.~~

Sub A177
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39. The heat sink material according to any one of
claims 26 to 38, wherein an element for lowering a melting
point is added to said metal (14).

40. ~~The heat sink material according to claim 39,~~
wherein said element to be added is Zn or the like.

SubA18)
5 41. ~~The heat sink material according to any one of~~
claims 1 to 40, wherein a carbide layer is formed on a
surface of said carbon or said allotrope thereof.

10 42. ~~The heat sink material according to claim 41,~~
wherein said carbide layer is formed on the basis of a
reaction at least between said carbon or said allotrope
thereof and the element to be added.

15 43. ~~The heat sink material according to claim 42,~~
wherein said element to be added is one or more of those
selected from Ti, W, Mo, Nb, Cr, Zr, Be, Ta, V, B, and Mn.

SubA19)
20 44. ~~The heat sink material according to any one of~~
claims 1 to 43, wherein said metal (14) is at least one
selected from Cu, Al, and Ag.

25 45. ~~The heat sink material according to any one of~~
claims 1 to 44, wherein a ratio of coefficient of thermal
conductivity is not more than 1:5 between a direction in
which said coefficient of thermal conductivity is minimum
and a direction in which said coefficient of thermal
conductivity is maximum.

46. A method of producing a heat sink material,
comprising the steps of:

sintering carbon or allotrope thereof to form a network
for obtaining a porous sintered member (12);

5 infiltrating said porous sintered member (12) with
metal (14); and

cooling said porous sintered member (12) infiltrated
with at least said metal (14).

10 47. The method of producing said heat sink material
according to claim 46, wherein in said sintering step, said
carbon or said allotrope thereof is placed in a vessel, and
an interior of said vessel is heated to produce said porous
sintered member (12) of said carbon or said allotrope
thereof.

15 48. The method of producing said heat sink material
according to claim 46 or 47, wherein in said infiltrating
step, said porous sintered member (12) is immersed in molten
20 metal of said metal (14) introduced into a vessel, and said
porous sintered member (12) is infiltrated with said molten
metal by introducing infiltrating gas into said vessel to
pressurize an interior of said vessel.

25 49. The method of producing said heat sink material
according to claim 48, wherein force of said pressurization
is four to five times as strong as a compressive strength of

SubA19) and
~~said porous sintered member (12) of said carbon or said
allotrope thereof, or less than four to five times the
compressive strength of said porous sintered member (12).~~

5 50. The method of producing said heat sink material
according to claim 49, wherein said force of said
pressurization is 1.01 to 202 MPa (10 to 2000 atmospheres).

SubA20)
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51. The method of producing said heat sink material
according to any one of claims 46 to 50, wherein in said
cooling step, said infiltrating gas in a vessel is vented,
and cooling gas is quickly introduced to cool an interior of
said vessel.

52. The method of producing said heat sink material
according to any one of claims 46 to 51,

wherein said sintering step includes a step of setting
said carbon or said allotrope thereof in a case (70), and a
step of preheating an interior of said case (70) to prepare
said porous sintered member (12) of said carbon or said
allotrope thereof, and

wherein said infiltrating step includes a step of
setting said case (70) in a mold (82) of a press machine
(62), a step of pouring molten metal (86) of said metal (14)
into said case, and a step of forcibly pressing said molten
metal (86) downwardly with a punch (84) of said press
machine (62) to infiltrate said porous sintered member (12)

in said case (70) with said molten metal (86).

53. The method of producing said heat sink material according to claim 52, wherein a pressure of said forcible pressing by said punch (84) is four to five times as strong as a compressive strength of said porous sintered member (12) of said carbon or said allotrope thereof or less than four to five times the compressive strength of said porous sintered member (12).

54. The method of producing said heat sink material according to claim 53, wherein said pressure of said forcible pressing by said punch (84) is 1.01 to 202 MPa (10 to 2000 atmospheres).

55. The method of producing said heat sink material according to claim 53 or 54, wherein said mold (82) is formed with a gas vent hole for venting any remaining gas in said porous sintered member (12) or formed with a gap for venting gas.

56. The method of producing said heat sink material according to any one of claims 46 to 55, wherein in said cooling step, said heat sink material, in which said porous sintered member (12) is infiltrated with said metal (14), is cooled by cooling gas blown thereagainst or by using a cooling zone or a cooling mold where cooling water is

Supplied.

57. A method of producing a heat sink material, comprising the steps of:

5 mixing water or a binder with powder (12b) of carbon or allotrope thereof to obtain a mixture;

forming the obtained mixture into a preformed product under a predetermined pressure; and

infiltrating said preformed product with metal (14).

58. A method of producing a heat sink material, comprising the steps of:

mixing powder (12a) of carbon or allotrope thereof with metal (14) dissolved into a liquid state or a solid-liquid co-existing state to obtain a mixture; and

casting the obtained mixture.

59. A method of producing a heat sink material, comprising the steps of:

20 mixing powder of carbon or allotrope thereof with powder (14a) of metal (14) to obtain a mixture (104); and

pressurizing the obtained mixture (104) placed in a mold of a hot press machine (102) at a predetermined temperature under a predetermined pressure to form into said
25 heat sink material.

60. A method of producing a heat sink material,

comprising the steps of:

mixing powder of carbon or allotrope thereof with powder (14a) of metal (14) to obtain a mixture (104);

preforming the obtained mixture (104) to prepare a preformed product (106); and

pressurizing said preformed product (106) placed in a mold of a hot press machine (102) at a predetermined temperature under a predetermined pressure to form into said heat sink material.

61. A method of producing a heat sink material, comprising the steps of:

mixing a pulverized cut material of carbon or allotrope thereof with powder (14a) of metal (14), and preforming to prepare a mixture (104); and

pressurizing said mixture (104) placed in a mold of a hot press machine (102) at a predetermined temperature under a predetermined pressure to form into said heat sink material.

62. A method of producing a heat sink material, comprising the steps of:

mixing a pulverized cut material of carbon or allotrope thereof with powder (14a) of metal (14) to obtain a mixture (104);

preforming the obtained mixture (104) to prepare a preformed product (106); and

pressurizing said preformed product (106) placed in a mold of a hot press machine (102) at a predetermined temperature under a predetermined pressure to form into said heat sink material.

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63. The method of producing said heat sink material according to any one of claims 59 to 62,

wherein said predetermined temperature is relatively - 10 °C to -50 °C with respect to a melting point of said metal (14), and

wherein said predetermined pressure is 10.13 to 101.32 MPa (100 to 1000 atmospheres).

64. The method of producing said heat sink material according to any one of claims 59 to 63, wherein said heat sink material is heated to a temperature of not less than a melting point of said metal (14) after said pressurizing step.

65. The method of producing said heat sink material according to any one of claims 46 to 64, wherein said metal (14) is at least one selected from Cu, Al, and Ag.